Australian Academy of Science Country Strategy Submission to the Asian Century Implementation Unit

As the international focus on Asia intensifies, Australia will face more competition for opportunities to collaborate with the region's most capable researchers. Sustaining Australia's present links will need continued investment and stewardship by governments, our leading scientists, innovators and institutions.

Australian Government (2012) *Australia in the Asian Century* White Paper

Introduction

Successive Australian governments, and governments throughout the world, have recognised that undertaking research and development to address national challenges is at the heart of increasing economic and social wellbeing, productivity, and competitiveness[1]. Improved living standards and resilience arise from the development of new technologies and their use in our community and across all sectors of our economy[2]. The recently released *Excellence in Research for Australia* report shows the high quality of Australian research being undertaken across a wide range of disciplines[3]. Australia has a relatively high research output, producing more than 3% of world scientific publications yet accounting for only about 0.3% of the world's population[4].

The nature of science, engineering and innovation is changing. Increasingly, efforts are undertaken collaboratively between multiple international researchers and institutions. Hence, Australia competes internationally for ongoing, ready access to the 97% of knowledge and knowledge development processes that occur overseas[5]. The government's recently released innovation statement, *A Plan for Australian Jobs*, makes clear that the benefits of international collaboration are considerable[6]. Providing strategic support for Australian researchers, institutions and industry to gain access to and share resources, data, ideas and risks with the rest of the world, including Asia, is essential to Australia's aims. Indeed, the Australian Academy of Science has long argued that if Australia is not a competitive collaborator, our future capacity to address domestic and global problems will be greatly diminished[7].

In our view, a policy and a strategic program for Australia's international scientific engagement is needed to ensure efficient, effective and appropriate engagement by Australia in the Asian Century via Australian research and development expenditure[8].

The Asian Century

The Asian Century brings new challenges and opportunities for international science collaboration[9] [10]. A growing proportion of global scientific research is taking place in Asia, and this will continue to grow as countries such as China, India, Japan, South Korea and others reap the benefits from their considerable (far greater than Australian) investment in science. As the White Paper correctly identifies, these countries already have world-class research infrastructure and capabilities, and

access to such endeavour and facilities can provide enormous opportunities and benefits for Australia, opportunities that we are not able to realise on our own[11].

Australia has established strong collaborative ties to both traditional scientific powers in North America and Europe, and with newly emerging scientific leaders in the Asia region. At the Academy level, our international work is based on Memorandums of Understanding (MoU) with the Science Academies in China (1980 – the first delegation from the Australian Academy of Science to China was in 1964), India (1986), Japan (1977), South Korea (1992) and Indonesia (1995, renewed 2013).

It should be noted that while well placed to strengthen existing international links, the five target countries have an R&D investment profile weighted more towards development, rather than research, and is thus a driver for their interest to collaborate on the research side.

There is considerable scope for undertaking mutually beneficial research with partners throughout the region[12]. However as such access is a competitive undertaking we need to improve greatly our situational awareness to inform our national research investment to nurture and grow collaborative opportunities if we are to be a partner of choice.

There is also scope to look at the possibility of developing a more coordinated approach to sharing major research infrastructure in the region.

With appropriate situational awareness, comparatively modest resources are required to foster collaboration. While Australian and foreign research funding agencies are, to varying extents, able to support internationally collaborative research on a competitive (scientific excellence) basis, scope to explore and develop collaborative relationships is needed if Australian researchers are to compete in the collaborative stakes.

At this time, for Australia, the window of collaborative opportunity is open but we are at risk of it closing soon[13]. Many eminent scientists working in Asia have very good relationships with Australian researchers, universities and research organisations. Many were trained here and are familiar with Australia's research capacities. However, given the boom in tertiary education and research in the past decade in Asia, and ongoing investment, it is unlikely that their upcoming researchers will have such familiarity with Australia as they do today.

The termination of the International Science Linkage (ISL) scheme in 2011 (then Department of Industry, Innovation, Science and Research), coupled with the increasing focus by government upon fee-paying overseas undergraduate and PhD students within Australia, creates an unfortunate impression that Australia is more interested in taking, than collaborating. The proactive use of Australian university alumni to foster research collaboration and counter unfortunate and or inaccurate impressions is a worthy idea that should be acted upon.

Australia should develop, promote and strengthen long-term bilateral agreements to support collaborative research programs with key countries in Asia. Bilateral agreements have been a successful initiative for research engagement with India and China, however these agreements need to support longer term programs and they need to extend to more key countries in the region. Proper resourcing of a collaborative policy is the best way to ensure stronger and deeper engagement with our strategic Asian partners.

An often overlooked point is that multilateral scientific collaboration provides Australia with the opportunity to develop not just our own direct relationships but also those of our partners with each other. For example, efforts to foster an Australian, Indian and Indonesian collaboration would strengthen relationships between Indonesia and India. Australian efforts to foster such relationship building and enjoy ongoing engagement with such development is very likely to be in Australia's interests.

It is of primary importance that Australia significantly improves Asian language skills of students at all levels. As with other fields of endeavour, scientific collaboration is realised by people communicating and working with other people, particularly in the early career years. Past Australian scientific collaborative success with non-English speaking researchers reflects not only foreign national research strengths but also the language skills of Australian researchers, ie. predominantly major European languages. Scientific collaboration success for the country strategies will therefore depend in part upon the significant improvement of Mandarin, Hindi, Japanese, Bahasa and Korean language skills and cultural awareness in Australian schools and universities.

The development of country specific strategies presents a welcome opportunity to set out how we intend to deepen relationships with regional partners. Within the framework of a whole of government policy and program to provide strategic support for international collaborative engagement, the Australian Academy of Science offers the following points to inform country specific strategies.

Country specific points

China

China has been investing heavily in research and development (R&D) over the past decade, increasing spending on R&D by about 20% per year. It is now the second-largest investor in R&D after the United States having overtaken Japan in 2009. In 2012 it was expected that central government expenditure on science and technology research would rise to US$36.1 billion, an increase of 12.4% on the previous year's spending[14]. It is worth noting that China has taken its R&D investment from 1.4% of GDP in 2007, to 1.97% in 2012, and of this investment 74% was made by business. Through developing strategic partnerships Australia can benefit from the outcomes of this investment.

A 2011 Royal Society report has shown that between 2004 and 2008 China produced 10% of the world's published scientific articles[15]. This put China second after the United States in terms of output. However, the quality of Chinese research while excellent in many cases is variable[16], with it receiving relatively few citations, and having few high-impact articles[17] [18]. It is clear that China intends to improve on the quality of its research and research outputs, and part of this will require an increase in international collaborations with other partners. There is a desire to work with Australian universities and research institutes, but Australia needs to be ready to respond to such collaboration requests, otherwise China will look elsewhere for its international collaborations. For example, if the Chinese Government offers a collaborative program valued at $100m (as allegedly occurred in the past) Australia should strive to match it dollar for dollar, rather than try to find ways of reducing its contribution.

China's substantial investment in science will mean that there are opportunities for collaborations right across the sciences, and in areas of interest to Australia such as agricultural research, environmental science, geoscience and space science. Such science investment is not limited to research and government institutes. With 74% of R&D in China being undertaken by business there is considerable scope for inward investment in Australian research, and partnership with Australian industry.

One example where new opportunities are arising is in nuclear science. China has moved from being a relatively unimportant player to becoming a leading force in the area. There are plans to bring on-line two new facilities every five years. The first of these major projects involves a major study of transmutation – an area vital to Australia's national interests. The second is the construction of a new high energy heavy ion accelerator. This has been augmented by a proposal to develop an electron-ion collider by 2019. If this is approved then this would be a world-leading facility, and would take China years ahead of the United States and Europe, presenting an opportunity for Australian involvement.

Successful collaborations require personal and ongoing links between researchers. These links are often developed at the early stages of a researcher's career. There is much potential to increase the number of researchers from China undertaking part of their doctoral research in Australia. The China Scholarships Council provides funding for students to complete part of their PhDs overseas. Having PhD students complete part of their research in Australia will help develop the ongoing long-term links that we need between our scientists. However to do this we need to be active in promoting Australia as a destination for such research. Cooperation agreements between top institutions would help raise the profile of our research endeavours and facilitate such opportunities.

As Chinese R&D expenditure is weighted more heavily towards development than Australia R&D, it would be sensible to give some emphasis to Australian research strengths with respect to Chinese development efforts, ie. Academic placements, exchanges or collaborative efforts with Chinese institutions with working linkages with industry. Likewise, consideration should be given to encouraging academic institutions in Australia to consider joint appointments with Chinese institutions, especially those with working relationships with industry.

It is important to recognise that how research decisions are made in China is very different to in Australia. This means that it is critical to develop strong links with key individuals and to build up enduring trust over the long-term.

In developing and maintaining links, continuity is crucial. The Australian Academy of Science has spent much time and effort in developing ongoing links with the Chinese Academy of Sciences. Since 1980 there has been a MoU between the two Academies and this has helped bring together a generation of researchers from the two countries, leaving Australia well placed to continue developing such strategic relationships. Activities under this MoU have included an exchange program for scientists as well as a series of annual symposia, initiated in 2004, and jointly organised by the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering and the Chinese Academy of Sciences.

Undertaking international research can be logistically and financially challenging. The traditional sources for research funding, such as the ARC, NHMRC and Cooperative Research Centres, are not

usually appropriate for international science endeavours. This has been recognised in the past through development of the Australia-China Science and Research Fund, and the former International Science Linkages programs. These programs have been invaluable in ensuring that Australian scientists have been able to engage with Chinese researchers and to bring back to Australia the benefits of China's ongoing and growing investment in science. However with no replacement International program, the Australian Academy of Science's exchange program for Australian and Chinese researchers ended in 2011 and with the Australia-China Science and Research Fund due to expire this year, Australia is not showing its potential partners that it is ready to invest for the long-term in both research projects and in developing ongoing links. The strong case for China investing in Australian science and research links is currently undermined by the lack of Australia's long-term commitment.

It should be noted that the Chinese Embassy in Canberra has two full time positions (Counsellor Science and Technology, and a Second Secretary, Science and Technology) that are fully committed to advancing bilateral research collaborations.

Recommendations:

- Continuing and enhancing the Australia-China Science and Research Fund that would fund among other activities an ongoing Australia-China exchange program for researchers and the annual symposia series
- Continuing to fund a full time (A-based) Science Counsellor at the Australian Embassy, Beijing, to be supported by dedicated locally engaged staff at Consulates
- Establishing formal opportunities for R&D exchanges involving both Chinese and Australian industry
- Undertaking proactive initiatives to promote joint appointments between Chinese and Australian institutions - consider visas, income tax and cultural consequences.

India

In the past India has tended to look towards the United States, Japan, Europe and in particular the UK for collaborations in science and technology. As the Indian tertiary education and research sector continues to develop, there exists significant opportunity to improve Australia's science collaborations with India. However Australia's reputation in India has suffered in recent times and this is evidenced by the significantly reduced number of students from India applying to study in Australia. A broad push to change perceptions of Australia within India should be part of any country strategy to enhance links between the two countries.

At present India spends 0.9% of GDP on R&D, and has ambitious plans to grow this to 2% by 2017[19], with growth to come predominantly through the private sector. Should this anticipated growth materialise, there is much opportunity for Indian businesses to invest in Australian science and technology. However such investment will only take place if we develop and nurture links so Australia is on the horizon when it comes to science investment. The Australia-India Strategic Research Fund has helped to kick-start the development of new links between Australia and India's scientists and researchers. The fund has brought about a number of significant new collaborations, which will bring strategic benefits for Australia and forge long-lasting partnerships that deliver benefits long after program funding ends. Unfortunately this strategic fund is set to expire within the

next two years, leaving Australia without the capacity to respond to the unprecedented opportunities that are set to develop in India over the next 10 years.

India has recently outlined plans to significantly increase its investment in science, but to realise the full potential of this investment it needs access to expertise. Between April 2012 and March 2017 it is expected that US$24 billion will be invested in R&D in six key scientific departments; this will be more than 2.5 times more than India spent on R&D in the previous five years[20]. This plan has included backing India's investment in the Square Kilometre Array (the world's most powerful radio telescope) currently being built in Australia, New Zealand and South Africa. Domestically, a neutrino observatory and a next-generation synchrotron have been given priority status for investment over the next five years. The plans also include increasing the number of PhD graduates each year from 8,900 to 12,500, and to increase the number of researchers from 154,000 to 250,000[21].

The plans are aspirational and will be challenging for India to meet. The science adviser to the Indian Prime Minister stated to *Nature* that 'Sometimes I worry whether we have enough good people to use the research funds'[22]. The new plans for science, and the concern at high levels that there are skills shortages represent an excellent opportunity for Australian scientists to forge new mutually beneficial partnerships, whereby they can offer expertise and leverage new opportunities for Australian science through this increased investment.

The Australian Academy of Science has had an MoU with the Indian National Science Academy (INSA) since 1986 and signed a new MoU in 2012 to better reflect the program of Fellowships for early career and senior researchers that each Academy currently administers for its respective government (DIICCSRTE in the case of Australia and the Department of Science and Technology and the Department of Biotechnology in the case of India.)

Recommendations:

- Continuing the Australia-India Strategic Research Fund
- Undertaking activities to enhance Australia's image in India
- Continuing to fund a full time (A-based) Science Counsellor at the Australian Embassy, New Delhi, to be supported by dedicated locally engaged staff at Consulates
- Establishing formal opportunities for industrial exchanges involving both Indian and Australian industry
- Undertaking proactive initiatives to promote joint appointments between Indian and Australian institutions - consider visas, income tax and cultural consequences.

South Korea

South Korea has been investing heavily in R&D over the past 25 years. In 2011 total expenditure on R&D was 4% of gross domestic product, and the South Korean government plans to increase this to 5% by 2017[23]. This investment is set to continue under the new South Korean government. The President of South Korea pledged during her election campaign that science and technology policy would become the cornerstone of her government's work[24].

South Korea has recognised that to enjoy the benefits of innovation, increased investment in basic science is required. In the past decade the South Korean government has doubled its budget for basic research to about US$5.4 billion[25], and it has doubled its number of researchers. The Institute for Basic Science (IBS) was launched in May 2012 and among other projects is set to construct a heavy-ion accelerator costing about US$460 million. With such state-of-the-art facilities the IBS is planning to attract at least 50 internationally renowned scientists as project leaders[26]. Australia needs to think strategically about how it might benefit from such large scale investments in science.

At present there is no accessible fund to support Australia's science collaborations with South Korea. This means that Australia is unable to benefit from South Korea's sustained investment in science. The new ideas and technology being developed in South Korea will be enjoyed by other nations who are in a better position to forge long-term strategic partnerships. For example South Korea has embarked on the development of a preliminary concept design for a fusion power demonstration reactor. This project is being undertaken with the US Department of Energy's Princeton Plasma Physics Laboratory (PPPL) in New Jersey[27].

Developing partnerships that lead to involvement in projects such as the above is a very competitive undertaking, and one that other nations take very seriously. Australia's capacity to compete and be a partner of choice, is currently minimal. At present Australia's science profile in South Korea is very low, and South Korea looks towards Japan, the United States and Europe for its science collaborations. Strategic efforts to raise Australia's research profile (capacity) in South Korea are urgently required..

It should be noted that Japanese firms once dominated the consumer electronics industry, but over the past decade they have been overtaken by Taiwanese, South Korean and Chinese companies. Samsung and LG are South Korean firms with whom Australian partners should collaborate, particularly in the area of organic electronic materials.

The Australian Academy of Science has had an MoU with South Korea (initially with the Korea Science and Engineering Foundation that is now known as the National Research Foundation – NRF) since 1992. This MoU is a joint one with the Australian Academy of Technological Sciences and Engineering. Under this MoU the Australian Academy of Science and NRF administered an exchange program of scientists, both early career researchers as well as senior researchers. With the ending of the ISL program the exchange program ceased due to lack of funding.

At the Australia- South Korea 2nd Meeting of the Joint Committee on Science and Technology between the DIICCSRTE and the South Korean Ministry of Science, ICT and Future Planning (MSIP) hosted by Australia on 20 May 2013, the South Korean delegation indicated its strong interest in strengthening collaborative links with Australia.

Recommendations:

- Establishing a dedicated (A-based) Science Counsellor position at the Australian Embassy, Seoul, to be supported by dedicated locally engaged staff
- Establishing an Australia-South Korea Science and Research Fund similar to those already in place for China and India, which will support an exchange program of scientists from both countries
- Establishing formal opportunities for industrial exchanges involving both South Korean and Australian industry
- Undertaking proactive initiatives to promote joint appointments between South Korean and Australian institutions - consider visas, income tax and cultural consequences.

Japan

Japan is one of the world's largest investors in science and research, making it an important knowledge producing nation. Australia has long recognised the importance of a mutually beneficial science and research relationship with Japan, and the two countries signed the *Agreement on Co-operation in Research and Development in Science and Technology* in 1980.

DIICCSRTE in collaboration with the Centre for International Economics has undertaken a comprehensive report on the current state of, and future opportunities for, science and research collaboration between Australian and Japan[28].

As the DIICCSRTE report states, Australia and Japan have economies of vastly different sizes, structure and recent growth trends, but expectations for greater contributions from science and research for future economic development are similar. Japan invests far more in science and research than Australia, employs more researchers and records much higher patent applications. Japan's science and research expenditure is dominated by the private sector, whereas in Australia it has only been in the past decade that the private sector has become dominant major source of science and research expenditure.

Compared to other large developed economies with significant science expenditure, such as Canada, US, Germany, UK and France, Japan has a lower level of international science and research collaboration, and its strongest collaborations are with the US, China and Germany, with Australia ranking only ninth in 2010. Joint scientific collaborations accounted for only 2.5% of Australian publications and 1.3% of Japanese publications in 2009. Australia's collaborations have been increasing much more rapidly with other developed economies and also some emerging economies in the Asia Pacific region such as China and India.

Many Australian science organisations have formal agreements for bilateral collaboration with Japan but according to the DIICCSRTE report there is limited evidence of a strategic, long-term approach to developing the depth and value of these collaborations in line with Australia's overall science and research priorities. The report makes it clear that whilst science and research agreements can lay the foundations for future collaborations, they need to be followed up with practical action.

Encouraging more international science and research collaboration is now part of Japanese Government policy. Japan has been focussed on developing collaborations in the Asia region,

particularly with China, South Korea and India, to ensure that Japan is at the heart of what is increasingly seen as a major node of global science and research.

There are a number of challenges that need to be addressed to improve science and research collaborations between Australia and Japan and these are identified in the DIICCSRTE report. They include mobility issues; organisational support; limited funding systems; and the lack of seed funding. The DIICCSRTE report discusses a number of practical steps that could be taken to help facilitate international science relations with Japan, including:

- Providing access to information from a range of sources about collaboration opportunities
- Providing expert advice based on first-hand experiences to help those without experience understand how processes work
- Promoting Australia's science and research capabilities and collaboration opportunities.

Since 1977 the Australian Academy of Science has had an MoU with the Japan Society for the Promotion of Science (JSPS) [29]. Under this MoU, an exchange program of researchers from both countries has taken place on an annual basis. Additionally, every year the JSPS fully funds 15 Postdoctoral Fellowships for Australian young researchers to conduct postdoctoral work in Japan. The JSPS also funds nine senior Australian researchers to visit Japan every year for short-term visits to conduct research and give lectures. Depending on the number of fellowships awarded each year, the JSPS can fund up to $2 million towards Australian participation in this fellowship program.

Due to the importance of this bilateral relationship DIICCSRTE has funded the Australian Academy of Science to continue the above programs in FY 2012-13 and FY 2013-2014 and conduct two scientific workshops in 2013.

The Japanese Embassy in Canberra has a Science Counsellor who is active in Australia and who maintains close links with the Australian Academy of Science.

In addition to pursuing the steps outlined in the DIICCSRTE report the Australian Academy of Science recommends:

- Establishing a dedicated (A-based) Science Counsellor full time position at the Australian Embassy, Tokyo, to be supported by dedicated locally engaged staff at Consulates
- Establishing an Australia-Japan Science and Research Fund similar to those already in place for China and India that will continue to support exchange programs and JSPS Fellowships schemes
- Matching the JSPS program with Australian funds
- Establishing formal opportunities for industrial exchanges involving both Japanese and Australian industry
- Undertaking proactive initiatives to promote joint appointments between Japan and Australian institutions - consider visas, income tax and cultural consequences.

Indonesia

Indonesia's innovation performance appears weak on various measures compared with other countries in South-East Asia and countries such as India and China. Based on the available data, Indonesia's gross expenditure on R&D (GERD) is less than 0.1% of GDP and most R&D is performed by public research organisations (PROs). Numbers of patent applications and scientific and technical publications are relatively small.

Indonesia's manufacturing output expanded by an average of 12% a year from 1998 to 2008, faster than the OECD average (9%), but short of the 22% average annual growth in the BRIICS group as a whole in 2000-08. In 2007, high-technology industries contributed a negative –0.9% to Indonesia's manufacturing trade balance[30].

From 2000 to 2008, exports in medium high-technology industries increased by 15%, below the 25% in the BRIICS group. Medium-high-technology industries contributed only modestly to trade during this period, and much of the manufacturing trade balance still relies on low-technology industries. An increasing number of countries in South-East Asia have made innovation a priority in recent years, and Indonesia is now emphasising science, technology and innovation (STI) as a source of future competitiveness.

Indonesia's National Medium-Term Development Plan 2010-14 mentions 'culture, creativity and technological innovation' among 11 development priorities. It highlights increasing the quality of human resources, including the promotion of science and technology, and strengthening the competitiveness of the economy.

The agenda of national research under the Long-Term National Development Plan 2005–25 includes seven research priority areas. Recently, a National Innovation Committee (KIN) was established, chaired by the President of Al-Azhar Indonesia University. The committee is an autonomous body consisting of 30 members and reports directly to Indonesia's President. It is too early to say how effectively the KIN will resolve major issues, such as raising STI awareness, securing more resources for STI activities, and building a more cohesive national innovation system by better mobilising and linking innovation stakeholders. Looking forward, improving coordination between the research performed in PROs and the needs of industry and society remains a challenge, as does the integration of education, industry and science and technology policies.

The World Bank is supporting Indonesian efforts to evolve into a knowledge-based economy through a new project designed to strengthen Indonesia's research and innovation capacity. The Research and Innovation in Science and Technology Project (RISET), approved by the World Bank's Board of Directors, supports Indonesia's endeavours in science, technology, and innovation[31].

Following the signing of a Memorandum of Understanding (MoU) on *Cooperation in Scientific Research and Technological Development* between Australia and Indonesia in 2005, both sides established the *Australia-Indonesia Joint Working Group in Science and Innovation, Research and Technology* in June 2007. One of the tasks of the Working Group is to increase research collaboration and scientific discussion between the scientists of the two countries, particularly in the following areas:

- Human Health - including infectious disease

- Agriculture and Food
- Environment – including energy and climate change
- Nuclear Science and Safety – including material testing and evaluation

The Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering signed an MoU with the Indonesian Academy of Sciences in 1995. The MoU has not been very active due to lack of dedicated funding. However as part of the government-to-government MoU, the Australian Academy of Science, on behalf of the DIICCSRTE, and together with the Indonesian Ministry for Research and Technology (RISTEK), has since 2006 organised a number of workshops with Indonesia on: human health including infectious diseases; agriculture and food security; and environmental science. Two of these workshops have involved Professor Sangkot Marzuki, the current President of the Indonesian Academy of Sciences, and Director of the Eijkman Institute in Jakarta. Professor Sangkot was made a Member of the Order of Australia, which was presented in 2010 for his strong commitment to strengthening bilateral collaborations between Indonesia and Australia. The award was presented by Ambassador Bill Farmer when he was the Australian Ambassador to Indonesia.[32].

Recently, the Australian Embassy in Jakarta, the Indonesian Academy of Sciences, and the Australian Academy of Science have been working on a speaker series that enables Australian researchers to visit Indonesia to give lectures in at least two cities. The President of the Australian Academy of Science, Professor Suzanne Cory AC FAA FRS will visit Indonesia in June under this activity and will sign a new MoU with the Indonesia Academy to reflect this new initiative.

The Australian Academy of Science also has links with Indonesia in relation to its science education programs *Primary Connections* and *Science by Doing.* As a result of a visit to Indonesia last year by Professor Denis Goodrum, the Australian Academy of Science's Executive Director of the *Science by Doing* program, a partnership between the South-East Asian Ministers of Education Organisation (SEAMEO) for Quality Improvement of Teachers and Education Personnel (QITEP) and the Australian Academy of Science has been established. The result of this partnership is a collaborative Indonesian-Australian pilot project, Promoting Real Australian Indonesian Science Education (PRAISE), that is funded by the Australian Government. In April 2013 four Indonesian educators visited the Australian Academy of Science in Canberra to work with the *Science by Doing* team. The Indonesian team is developing a science curriculum unit for Indonesian students. The resource will be written in Bhasa, and will embrace the challenges of large classes, limited materials and local teaching expertise. The unit will be trialled at the beginning of the Indonesian school year in September 2013. If the pilot is successful, this curriculum unit can be used as a model to develop a full suite of units for secondary science education in Indonesia.

The US is already increasing its level of engagement in science and technology in the Asia-Pacific region. Collaboration is intensifying between Indonesia and the US with the 2010 signing of a new science and technology agreement and the 2009 appointment by President Obama of three special science envoys, including one for Indonesia, Professor Bruce Alberts. Professor Alberts has recommended helping Indonesia bolster its science education system, partnering to create a national science foundation to provide science research grants, and tripling the number of Indonesians studying in the United States and the number of Americans studying in Indonesia. *The Frontiers of Science* program, a young-scientist exchange effort of the US National Academy

of Sciences with Indonesia started in 2010. Prof Sangkot has been heavily involved in this initiative.

Recommendations

- Establishing a dedicated (A-based) Science Counsellor Science Counsellor full time position at the Australian Embassy, Jakarta, to be supported by dedicated locally engaged staff
- Providing institutional support to the Indonesian Academy of Science
    - To assist their Charter objective to improve
        - Scientific excellence (tertiary and research level)
        - Science education (primary and high school level)
    - To facilitate early to mid-career researcher exchanges between Indonesia and Australia
    - To foster collaborative research upon common national research priorities

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